

## II.—On the Developmental History of the Stomapoda.

By Dr. FRITZ MÜLLER, of Desterro\*.

[Plate II.]

UNDER the name of *Zoëa* we have long known young states of the Crabs and Hermit-Crabs, distinguished especially by the want of the ten feet to which the adult animals are indebted for their name of Decapoda. I have recently described the *Zoëa*-forms of the *Porcellanæ* as those approaching most closely to those of the Crabs. But in certain Prawns and Stomapoda, as I have since ascertained, similar conditions occur. Of the metamorphosis of the former, which commences sometimes (as in the Cirripedia and Rhizocephala) with Monoculoid forms and passes through very peculiar *Zoëoid* and *Mysis*-like states, and sometimes with *Zoëa*-forms which in structure and mode of movement resemble those of the Hermit-Crabs, whilst in others we can hardly say that there is any metamorphosis, I hope shortly to be able to give a tolerably complete account. In the case of the latter I have at present no prospect of fresh observations, and therefore communicate what I have recorded upon the only larva yet discovered.

The little animal (Pl. II. fig. 1), which is 3·25 mill. in length, has the general form and likewise all the glassy transparency of an *Alima*. The segments exist in almost the same number as in mature Stomapods, only the sixth and seventh abdominal segments being not yet distinct from each other; as in the *Zoëæ* of the Crabs and *Porcellanæ*, the appendages of the six hinder thoracic segments† and the lateral laminae of the caudal fin ‡ are still entirely deficient.

\* Translated from Wiegmann's Archiv, 1862, by W. S. Dallas, F.L.S.

† I have never been able to reconcile myself to the exceedingly forced notion which limits the thorax of the Crustacea, like that of Insects, to three segments. It is contradicted, as appears to me, by the developmental history of those Crustacea which are subject to a metamorphosis, whilst the ordinary and readily perceptible division between the thorax and abdomen is confirmed thereby. It is only a reference to the Insecta that could have led from this and to that new artificial line of demarcation. But if any Crustacea can be compared with certainty (as regards the divisions of the body) with Insects, these are certain *Zoëa*-forms (e.g. of *Pagurus*) with three pairs of buccal organs, three pairs of legs, and an abdomen destitute of appendages. These three pairs of feet certainly become the foot-jaws of the Crab in accordance with the notion referred to; but the five pairs of true feet of the Crab are produced, not from the abdomen of the *Zoëa* whilst a new "postabdomen" sprouts forth behind, but they are formed *in front* of the abdomen, and often simultaneously with and in the same form as the third pair of foot-jaws. They are to be regarded as an addition to the thorax which is entirely wanting in Insects; and here, again, the process is repeated, that after the appearance of new posterior legs the anterior ones give up their original function, and become feelers or manducatory organs.

‡ The distinction of the last two abdominal segments, which usually

The *carapace*, which leaves the three hindmost thoracic segments uncovered, is flat, and scarcely, if at all, bent down laterally. Its posterior part has nearly the form of the so-called Sea-Mouse, or of a quadrangle with its corners drawn out into points directed backward and forward, with its fore and hind margins of equal width (about two-thirds of the length), and its sides gently arched. The posterior margin is notched in the middle as far as it lies upon the body. The anterior angles lie over the origin of the posterior antennæ; between them the carapace is produced forward, becoming rapidly narrower and running out into a point, which projects beyond the body about one-sixth of its length. The length of the anterior portion of the body, covered by the carapace, is to that of the posterior uncovered portion about as 3 : 5.

The foremost division of the body (fig. 2), bearing the eyes and antennæ, which is almost entirely filled by a large nervous mass, has a quadrangular form; it is 0·28 mill. in length, and the same in breadth behind; the width in front is only half as much; on the middle of its lower surface stands a short spine directed forward. From its anterior angles spring the *eyes*, the extreme convexities of which, when turned quite laterally, are 0·5 mill. apart; one-third of this distance is due to the frontal margin and the slender basal joints of the peduncles. The terminal joint of the eye-stalk forms an oblique cone, the anterior margin of which is about two-thirds the length of the posterior margin; the latter is about equal to the diameter of the basal surface, over which the true eye arches itself.

Below the frontal margin, in the middle of a semicircular process, is seen a small black *single eye*, which perhaps indicates that even here the development commences with monoculoid forms.

Rather nearer to the eyes than to the posterior antennæ, the *anterior antennæ* spring from the margin of the body; they have a three-jointed stem, a two-jointed upper branch, and a jointless inner lower branch, and attain one-fifth of the length of the body. Of the three joints of the stem, the intermediate one is half the length of each of the other two; the first joint is cylindrical, the third thickened at the end. The upper branch is slender, as long as the stem, and bears a long bristle at the end of the first and two at the end of the short second joint. The inferior branch is of a pointed conical form, shorter, but far thicker, than the upper, with a long terminal bristle; about the middle of its upper surface it bears six thin cylindrical filaments

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differ so remarkably from the preceding ones, under the special name of the tail, may also be justified from the developmental history of the animal under notice.

or "bacilli," with rounded apices and very delicate outlines (Pl. II. fig. 3). The three upper of these are about 0·2 mill. in length; the three lower ones attain only one-third of this length.

With regard to these "bacilli" on the inner antennæ of the Crustacea, I may be permitted to make a slight digression. These structures, to which attention has lately been called amongst the lower Crustacea by more than one writer\*, appear to be very generally diffused throughout the class. I have found them in different Copepods, in the larva of *Balani* and *Rhizocephala*, in young *Bopyri*, in *Tanaïs* and other Isopods, in *Caprella*, in many *Gammarini*, in *Hyperia*, *Cuma*, and *Bodotria*, and in all stalk-eyed Crustacea which I examined for them. I missed them only in some parasites (*Bopyrus*, *Cymothoa*) and Crustacea inhabiting the land (*Ligia*, *Orchestia*). Of two species of the last-named genus found here, they are wanting in the one, whilst the other possesses them †. In their number and arrangement, size, and form, they are subject to great variety. I have found a single bacillus in many Isopoda (Pl. II. fig. 15), and in the middle of the antenna in a Copepod (fig. 18); a fan of about ten bacilli occurs in the young of *Bopyrus* (fig. 13). In Isopoda, *Caprellæ*, and Amphipoda, one or two usually stand at the apex and on the lower surface of the joints of the flagellum, sometimes on all the joints, sometimes with the exception of the basal one (figs. 14, 17). In *Squilla*, in which the outer branch of the inner antenna is again divided, I found them to the number

\* Schödler saw them, in 1846, in *Acanthocercus*; Leydig, in 1851, in *Branchipus*, and subsequently in *Polyphemus* and other Daphnidæ; Max Schultze, in 1852, in larvæ of *Balanus*. "The peculiar pod-shaped, stalked appendages" (fig. 12) which I met with, in 1846, on the third and following joints of the flagellum of the inner antennæ of the *Sphæroma* of the Baltic may belong here, notwithstanding the difference of their form.

† Note by Max Schultze:—The structures under discussion are described more in detail than in the passages known to Fritz Müller, by De la Valette in his inaugural dissertation 'De Gammaro puteano,' 1857, by Leydig, 'Naturgeschichte der Daphniden,' 1860, pp. 42–46, and most accurately by the same author in the 'Archiv für Anat. und Physiol.,' 1860, 'Ueber Geruchs- und Gehörorgane der Krebse und Insekten,' p. 281. Leydig, like Fritz Müller, comes to the conclusion that the structures are, in all probability, organs of smell. It does not appear, however, from Leydig's statements, what is to be regarded as essentially characteristic of the appendages which are to be interpreted as organs of smell; but, independent of their position on the antennæ (in the Crabs on the inner pair), their abundance of nerves and a certain delicacy of the external membrane, the obtuse apices and the appearance of an orifice in these, may be regarded provisionally as characteristic. According to this, the bristle-like feelers first described by me in larvæ of *Balanus*, as issuing near the eye (Zeitschr. für Wiss. Zool. iv. p. 191), and overlooked by later observers, but again met with and classed as organs of smell by Fritz Müller, would rather be tactile organs.

of three at the extremity of the last fourteen joints of the shorter, 42-jointed branch. In the Decapoda they appear usually to occupy the commencement of the flagellum, leaving the extremity free. This is the case in *Mysis*, in one species of which (fig. 10) they are condensed upon a peculiar process. So also in Crabs, *Porcellanæ*, and *Paguri* (fig. 8), in which they occur in the greatest number and of the largest size (up to 1 mill. in length), and, forming one or more transverse rows, beset the thick short joints of the branch, which rapidly diminishes from its thickened base. When the anterior antennæ serve as feet, the bacilli are wanting, as in the larvæ of Prawns\*; or they spring from the body itself, as in the larvæ of *Balani* and *Rhizocephala*.

The bacilli are generally simply cylindrical; I found them dilated into a bulbous form at the base, and here furnished with a tougher membrane, in *Squilla* (fig. 11), in a small Prawn (*Hippolyte*? fig. 9), and in *Ocypoda*. The extremity is usually rounded off in a hemispherical form, and sometimes exhibits a small strongly refractive spot. In the Prawn just mentioned (fig. 9 a) a short delicate point was appended to the rounded extremity. Sometimes they are narrowed towards the extremity: I found them thus in *Pagurus*; here, as in the Crabs and *Porcellanæ*, they are divided by delicate annular furrows into shorter or longer segments, and conically pointed. In the larger bacilli the contents sometimes appear delicately striated longitudinally, or very fine granules arranged in longitudinal rows are seen in them.

What is the function of these bacilligerous flagella? If we are unwilling to assume a sense entirely deficient in us inhabitants of the land (in favour of which, however, the rudimentary condition of the inner antennæ in terrestrial Crustacea, such as *Onisci*, *Orchestia*, and *Ocypoda*†, might be adduced), we can scarcely avoid considering them as organs of smell. In the Crabs, in which their bacilli are most highly developed, they are unadapted for feeling solid bodies, on account of their position, their inconsiderable length, and even on account of their bearing these delicate and readily injured appendages. From perceiving movements in the water, for which they would appear to be but ill adapted even on account of their shortness, they are prevented by a rapid current passing by and over them from the mouth. In a current of this kind, running from the mouth, we should certainly not seek for organs of taste. Thus, of our five senses,

\* The antennæ of the Prawns are metamorphosed swimming-feet; the swimming-feet of the *Daphniæ* are, however, hardly "transformed antennæ."

† In *Gelasimus*, also, I find the bacilli unusually delicate and short.

only smell remains. This cannot be deficient in animals which may be attracted by a strong-smelling bait. If we now consider how the inner antennæ of Crabs, *Porcellanæ*, and *Paguri* are in almost uninterrupted motion, as it were feeling through the water, which passes over them in a constant stream, by short, rapid strokes with their tufts of bacilli, we must consider them just as well adapted for the perception of odours as the parts in the basal joints of the inner and outer antennæ hitherto indicated as organs of smell appear ill fitted for that office, the latter wanting the most indispensable requisite of an organ of smell, namely, the ready and free access of water.

To return to our larva.

The *posterior antennæ* likewise spring from the margin of the body at the posterior angles of the above-mentioned quadrangular part bearing the eyes and antennæ; they are scarcely shorter than the anterior, and consist of a two-jointed stem and a laminar apical joint, somewhat dilated and beset with bristles towards its rounded extremity, equal in length to the stem, and directed backwards in repose. The jointed flagellum of the mature Stomapod does not appear.

The *mouth* is situated in the middle between the four lateral angles of the carapace; before it is a large helmet-shaped *labrum*; at its sides the *mandibles* (fig. 4), apparently destitute of palpi, each armed with three pointed teeth, which increase in length backwards, and are again finely denticulated on their anterior margin. Then follow two pairs of weakly developed *maxillæ*; the anterior (fig. 5) has two branches, each armed with three spine-like bristles and a minute palpus; the posterior (fig. 6) is a completely unjointed longish stump, with a few bristles at the end.

The feet of the following pair are thin, slender, and five-jointed, and reach to the sides of the mouth anteriorly, nearly to the origin of the posterior antennæ; their last two short joints are usually turned inwards and backwards.

Close behind these spring the large *prehensile feet*. The little animal likes to carry them widely extended as it hangs perpendicularly in the water (fig. 1). The basal joint then reaches outwards to the margin of the carapace; the second and third form a stalk slightly thickened towards the extremity, and 1 mill. in length, which, being directed obliquely upwards, reaches to the level of the eyes; the fourth joint is short and not distinctly separated, and unites the stalk with the horizontal palm, 1 mill. in length, which is slightly clavate and bears on its straight inner margin one long spine and a series of very short ones. Lastly, the claw is slightly curved, not denticulated, and about two-thirds the length of the palm. At the base of

the raptorial feet there is a small, roundish, laminar or vesicular appendage.

The raptorial feet are followed by six segments destitute of appendages: of these the three anterior, which are covered by the carapace, but not amalgamated with it, increase in length backwards in the proportion of about 2 : 3 : 4; taken together, they are half the length of the three posterior ones, which are equal to each other. The six rings together are 0·75 mill. in length; their breadth is 0·2 mill.

The following five segments, which together make up fully one-fourth of the length of the body, are about one-half broader, somewhat constricted at the articulations, and each armed at its posterior angles with a short spine. The four anterior of these five segments bear natatory feet (fig. 7), which are all constructed in the same manner:—a large basal joint, 0·3 mill. in length, and somewhat dilated at the extremity, bears two terminal laminae of about half that length, and beset with bristles; of these the inner one has a small finger-like process towards the end of its inner margin. The branchiæ are still entirely wanting.

The tail, consisting of a single piece, forms a large quadrangular lamina of about one-fifth the length of the body, and scarcely less in breadth; its lateral margins are gently arched, and its hinder margin slightly emarginate; sixteen minute denticles stand in this emargination, a somewhat longer one at each posterior angle, and six on each lateral margin.

The only Stomapod with which I am acquainted here is a *Squilla*, differing little, if at all, from *S. Mantis*. The larva described will probably belong to this. Young *Squilla* of the same species, of about 10 mill. in length, are already exactly similar to the mature animal, except in the smaller number of joints in the antennæ, of teeth on the raptorial feet, of branchial filaments, and the like. They had still the glassy transparency of our larva, and possessed like it a median eye.

#### EXPLANATION OF PLATE II.

Fig. 1. *Zoëa* form\* of a Stomapod from the Sea of Santa Catharina; magnified 15 diameters.

Figs. 2-7. Different parts of the same; magn. 90 diam.

2. Anterior part of the body, from below.
3. Anterior antenna, from the side.
4. Mandible.
5. Anterior maxilla.

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\* I would extend the name of *Zoëa* to all larvæ of Crustacea possessing two pairs of antennæ, three pairs of buccal organs, and two or three pairs of legs on the thorax, but still destitute of the five or six last pairs of thoracic feet.

Fig. 6. Posterior maxilla.

7. The last two segments of the thorax and the first of the abdomen, with one of its natatory feet.

Figs. 8-18. Bacilli from the inner antennæ of various Crustacea, magn. 90 diam. (except figs. 10, 12, and 16): *s*, stalk; *a*, outer, and *i*, inner branch of the antenna; *v*, blood-vessel.

8. From a small *Pagurus*; 8 *a*, apex of one of the bacilli.

9. From a small Prawn (*Hippolyte?*); 9 *a*, apex more highly magnified.

10. From *Mysis*; magn. 45 diam.

11. From *Squilla*.

12. From the *Sphæroma* of the Baltic; magn. unknown.

13. From a young *Bopyrus*.

14, 15. From two different species of *Tanais*.

16. From *Caprella*; magn. 180 diam.; *g*, ganglion(?).

17. From *Gammarus*.

18. From a Copepod.

III.—*Lucernaria the Cœnotype of Acalephæ*. By Prof. HENRY JAMES CLARK, of Harvard University, Cambridge\*.

THE present communication is a mere sketch of a most thorough and exhausting anatomy of *Lucernaria*, which I have illustrated by numerous plates, and which I propose to publish in an extended memoir, in connexion with some considerations upon the general morphology and systematic relations of Acalephæ. I have been engaged during the whole of the past year upon the organical and histological anatomy of this animal, in order to determine what are its relations to Radiata in general, and to Acalephæ in particular. I have had abundant materials for study, inasmuch as this species of *Lucernaria* is a very common inhabitant of our shores, wherever the eel-grass (*Zostera marina*) grows. Almost invariably *Lucernaria* is to be found upon the *Zostera*, and very rarely upon any other plant. It may be obtained from the last of August, when it is most frequently met with in a young state, until the last of June, at which time the young ones of the autumn season have developed to full-grown animals. In an adult state it measures nearly an inch across the disk, exclusive of the tentacles, and about the same in height. It varies in colour from green, which is the most common tint, to deep olive; from light yellow to reddish brown, or from light violet to the deepest purple. In form it is octagonal, and most frequently it so comports itself that the four sides opposite the bifarious genitalia are shorter than those alternating with them; but frequently the same individual reverses the order of things, and the latter become either as short as or even shorter than the first. From this we infer that the specific differences, based

\* From Silliman's American Journal for May 1863.